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Charles [illegible] Edwards presen[illegible]
his Preceptor C. [illegible]
Professor of

AN ESSAY

ON THE

CONNEXION OF LIFE

WITH

RESPIRATION

IN

NEWBORN ANIMALS,

OR

AN EXPERIMENTAL INQUIRY

INTO THE

PHENOMENA ATTENDING THE LIFE AND DEATH OF ANIMALS

BROUGHT FORTH IN DIFFERENT MEDIA.

BY WILLIAM PURNELL,

Of Maryland,

Member of the Philadelphia Medical Society.

Arteria animam accipit é pulmonibus. Cicero.

PHILADELPHIA:

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1811.

AN

INAUGURAL DISSERTATION

FOR

THE DEGREE OF

DOCTOR OF MEDICINE,

SUBMITTED

TO THE EXAMINATION

OF THE

REV. JOHN ANDREWS, D. D. PROVOST,

THE

TRUSTEES AND MEDICAL PROFESSORS

OF THE

UNIVERSITY OF PENNSYLVANIA,

ON THE

TWENTY-FIFTH DAY OF APRIL,

1811.

TO

WILLIAM P. DEWEES, M. D.

LECTURER ON MIDWIFERY, IN PHILADELPHIA.

Dear Sir,

A PUBLIC declaration of the pleasure and satisfaction which I have derived from your instruction, is only announcing to the world what I presume you have witnessed yourself; and in a more impressive and satisfactory manner than formal letters could convey or inadequate language express.

Permit me therefore to dedicate to you, as a mark of gratitude friendship and esteem, this imperfect essay, the first product of a medical education, conducted under your direction. And be assured it comes from a heart deeply impressed with a sense of its obligations to your goodness.

Please to accept also sir, of my warmest acknowledgments for the many opportunities of improvement afforded by yourself; and believe me, the many evincing proofs of disinterested

friendship and polite attention with which you and your amiable consort have honored me during my residence in your family, will ever be held in lively recollection.

With unfeigned wishes for your future health and happiness, together with an extension of that professional celebrity to which you may so justly lay claim, I subscribe myself

Your ever grateful

Friend and pupil

William Purnell.

TO

DOCTOR STEPHEN WHITE,

OF MARYLAND,

This essay is respectfully inscribed as a tributary offering, for the kind advice afforded by you previous to the commencement of my medical studies in Philadelphia, and for the attention with which you have ever honored

Your obliged friend

The Author.

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INTRODUCTION.

IN entering on the subject of the present essay, I feel as if I were about to tread a path thickly strewed with thorns; but am encouraged at the same time by the hope, that fortitude will enable me to withstand the severity of their points, though I should not succeed in obtunding them.

This inquiry was commenced with a view rather to satisfy curiosity by repeating an experiment, whose fallacy, subsequent reasoning and experience had not completely detected, than as a subject worthy of philosophical investigation. But, during the progress of these inquiries, several new and interesting phenomena presented themselves: to explain which in a rational manner, greatly increased my difficulties, and taught me the importance of the pursuits in which I was engaged.

This led me to consider the inquiry in a new light, and as more intimately connected with the physiology and life of man, than I had hitherto conceived it, and induced me to give to this essay the title which it now bears. The subject is certainly an important one, and demands our greatest attention; but should the present view of it appear superficial to an intelligent reader, let him remember that, it is intended more to prompt others, whose time and opportunities are greater, and whose talents are more adequate to the task, than as a complete elucidation of a subject involved in, as yet, much doubt and obscurity. However, I am inclined to believe, that many of the clouds, in which it is at present enveloped, may be dissipated by causing animals to bring forth

their young in different media: as water, common air, the different kinds of factitious airs, or gases, or even in vacuo, by observing carefully the different phenomena attending the life and death in each, and collecting and comparing the different results. Some of the effects of the two first of these I have tried; the result of which will be detailed in this essay; but to use the words of Dr. Goodwin, "As the testimony of the senses is not always sufficient, and the most careful inquirer may sometimes err, I neither expect or even wish the conclusion should be adopted, until the experiments should have been repeated by others; and if it be afterwards proved, that I have been mistaken in any part of them, I shall readily retract the assertion, and acknowledge the error, for the interest of truth and the welfare of mankind."

SECTION FIRST.

An examination of some of the peculiarities of the fœtus in utero, and the changes which take place immediately after birth.

IN order that a constant communication may be kept up between the fœtus and its mother for support and nourishment, it is necessary it should possess several peculiarities in the parts employed for the circulation of its blood.

Observation has proved that the communication between the ovum and uterus takes place several weeks after it is conveyed there. Previous to this union, the embryo is said to derive its nourishment alone from the medium by which it is surrounded; as the chick in ovo does from the albumen and yolk. From this time it undergoes a gradual development, until the end of the ninth solar, or tenth lunar month; which is the natural term of utero-gestation in the human female. If we examine the fœtus at this period, we shall find it contained in its proper coverings, and attached to the uterus by means of the placenta and umbilical cord.

Placenta.....The placenta is a spongy mass composed chiefly of blood-vessels and cellular substance. Two arteries and a vein constitute the greatest part of its bulk. These vessels ramify so extensively, that by injection we are enabled to fill nearly the whole mass. But when we attempt to inject the vessels of the placenta from the maternal vessels, we find it never to occupy but a certain portion of them, which has from this circumstance been called the maternal portion. Injections have never yet been made to pass into the vessels of the fœtal portion of this mass; while, on the contrary, none have ever been pushed from either the umbilical arteries or vein in the maternal portion. Again, when injections have been forced into either artery or vein of the placenta, we find they are reciprocally filled to a certain extent.

The *umbilical vein*, which is formed by the union of a number of small branches, supposed to originate partly from the extremities of the umbilical arteries, and partly as absorbents from the internal portion of the placenta, is of considerable size: it detaches itself from the placenta and passes on to the umbilicus of the fœtus, there enters the abdomen, and ascends, inclining towards the right side, supported by a duplica-

ture of peritoneum, as far as the liver, through a fissure of which it passes and gives off a number of branches to the lobes of this viscus. When it has proceeded as far as the right extremity of the transverse ridge, it appears to terminate and send off two lateral branches, which after birth become the sinus of the vena portarum; and one branch, which continues in the original direction to one of the hepatic veins, is denominated *ductus venosus*.

Foramen Ovale....The heart of the fœtus has, like the adult heart, two auricles and as many ventricles, with the large vessels common to it: namely, the vena cava, superior and inferior, terminating in the right auricle, and the pulmonary artery arising from the right ventricle; while the pulmonary veins terminate in the left auricle; and from the left ventricle originates the aorta. But there exists a communication between the right and left auricle, of an oval or rather roundish shape, known by the name of foramen ovale. This has to a certain degree a valvular structure opening from the right to the left auricle.

Ductus Arteriosus.....The pulmonary artery, originating from the right ventricle, sends only

two small branches to the lungs, but inosculates by a large branch, under the name of ductus arteriosus with the aorta below its arch, immediately below the subclavian artery.

The *internal iliac* arteries of the fœtus, instead of proceeding to the inferior parts of the pelvis, seem to distribute only a few vessels to those parts; the two arteries then take a curved direction on the side of the urinary bladder, pass through the umbilicus, and have received the name of *umbilical* arteries.

Funis.....The umbilical arteries and vein are enveloped in the same membrane, and thus constitute the funis or navel-string. These arteries are in general much larger than the vein, and for the most part are found taking a spiral turn round it, until their final termination in the placenta; in the substance of which they are lost by the minuteness of their divisions.

Peculiarities of the Fœtal Blood.

Fourcroy found by his experiments on the blood of the human fœtus, that it differed from the adult in the three following particulars.

1. Its colouring matter is darker, and seems to be more abundant.

2. It contains no fibrina, but probably a greater proportion of gelatine than blood of adults;

3. It contains no phosphoric acid.*

Circulation of the Fœtal Blood.

Mr. John Bell of Edinburgh is of opinion, that the peculiar construction of the fœtal heart and vessels is designed to give to the blood of the aorta the propelling power of both ventricles; and that the heart of the fœtus may be considered as a single heart though it becomes double from the changes which take place after birth.

Saumarez objects to this, and observes, that "it is very true that the fœtus has but one single heart. The comparative smallness of the waste, that it sustains, renders it necessary that the motion of the blood should not be so rapid as in the adult, where the waste of the system is very considerable. The conclusion therefore, continues he, is an erroneous one, which supposes the ductus arteriosus is especially designed to give to the blood of the aorta the propelling power of both ventricles.

* Vide Thomp. Chem. vol. IV. p. 593.

"If this were the design of this construction, he adds, the consequence would be, that the motion of the blood through the fœtal system would be much more rapid than it would through the adult; and, instead of a portion of the blood flowing through the right auricle through the foramen ovale to the left, the whole would go to the right ventricle, in order that its contractile power might be more eminently exerted by a more abundant quantity of blood."

But he again observes, "that the motion of the blood in the fœtal system is much slower than in the adult; and that the contractions of the heart are so imperceptible and easy that they generally cannot be detected ab externo. This he satisfactorily ascertained by examining a child which was brought forth with the membranes entire."—Saumarez Phys. vol. II. p. 32. et seq.

Now I cannot conceive why the whole of the blood should go to the right ventricle, in order that its contractile power might be more eminently exerted, by a more abundant quantity of blood, or (admitting the contractile power of the fœtal heart to be weak, which I believe to be the case,)*

* Dr. Dewees says, that after rupturing the membranes, in order to turn the fœtus, he has on examination invariably found

why the propelling power of both ventricles should not be given to the blood of the aorta, in order to effect the circulation through the long rout of the umbilical cord and placenta.

Believing therefore the observations of Mr. Bell to be plain and well founded, I shall take the liberty to quote him on the circulation of the fœtus, and function of the placenta.

"Let it be observed," says this author, "that every drop of blood that comes into the system is, or by communion with the mother's system, becomes oxydated blood.

"One part of this blood, indeed, passes through the circulation of the liver before it reaches the heart, while another passes more directly through the ductus venosus; but both are mixed: and the blood is all of one quality when it arrives at the auricle, in order to fill the heart, and to begin its course round the body. Now, since the blood is

the pulsations of the umbilical cord to be less in number than the pulsations of the radial artery of the mother.—*MSS. Lectures.*

The contractions of the fœtal heart may also be weaker; as the united force of both ventricles, though not so strong, might propel the blood through the aorta with greater velocity than the left ventricle of the adult, which alone drives the blood into the aorta.

all of one quality, Nature could have no cause for dividing such blood into two portions: one to pass through the lungs; the other to pass over the body. She could have no motive for employing, as in the adult, two hearts. The design of nature plainly is, to prepare a double heart, and keep it in reserve for the adult, but to use it as a single heart in the fœtus. And see how simply this is accomplished: The two auricles communicate so freely by the foramen ovale, that they are as one; the two ventricles deliver their blood into one vessel, the aorta; and they are also as one. The blood arrives by the cavas, fills the right auricle, and in the same moment fills, through the foramen ovale, the left auricle; so that the auricles are as one, and filled by one stroke; the two auricles act at once, and so the ventricles also are filled by one stroke; the aorta receives the blood of both ventricles at one stroke. So that in the strictest sense of the word, the fœtus has but one single heart, the heart of the body (the function of the lungs being performed by the placenta, far from its proper system;) and when the function of its lungs begins, then nature, by the simplest of all mechanisms, divides the two hearts, that they may perform each its peculiar functions. First, the flow of blood into the lungs deprives the

ductus arteriosus of blood; and, secondly, this flow of blood coming round to the left auricle of the heart restores the balance, presses down the valve of the foramen ovale, and makes the partition between the auricles entire. In short, while the oval hole and ductus arteriosus are open, it is a single heart; and when they close, as they do immediately after the child is born, it becomes the double or perfect heart.

"Now the mistake," continues our author, "which all physiologists have fallen into is this: they have not observed that no creature can live with a single heart, which has the oxydation of its blood performed by lungs. A fish lives with a single heart, because its blood is oxydated by gills, not by lungs. Insects live with a single heart, as their lungs, or the branches of their lungs are distributed like arteries over all their body. The fœtus can live with a single heart, because the blood is oxydated by the placenta. And that this idea may make a more determined impression, it will be good to prove, that the function of the placenta is actually equivalent to the lungs; and that it is the placenta itself that produces this change upon the blood, I am rather inclined to believe, because we see the veins and arteries of the chick spreading over

the membranes of the egg; and we can observe the arteries sending dark colored blood into these membranes, while the vein brings back florid or oxydated blood."—Bell's Anatomy, vol. II. p. 184. et seq.

Although the different organs of the fœtus are in a passive state previous to birth, they certainly possess a capacity to act, and to discharge their proper functions when roused by their appropriate stimuli; the eye to see, the ears to hear, the tongue to taste, the nerves to feel, the lungs to respire, and the stomach to digest. This aptitude of the different organs to commence action at birth is well described in the following lines:

> Erewhile, emerging from its liquid bed,
> It lifts in gelid air its nodding head;
> The light's first dawn with trembling eyelid hails,
> With lungs untaught arrests the balmy gales;
> Tries its new tongue with tones unknown, and hears
> The strange vibrations with unpractised ears;
> Seeks with spread hands the bosom's velvet orbs,
> With closing lips the milky fount absorbs
> And, as compressed the dulcet streams distil,
> Drinks warmth and fragrance from the living rill.
>
> ZOONOMIA.

The lungs immediately after birth in a perfect and healthy newborn animal always begin to

perform their office, provided there be no obstacle to the entrance of air; but the animal may live some time independent of the lungs, should the attachment of the placenta continue; but in proportion as the action of this may decrease, will the necessity be for the establishment of respiration.

Lungs.....The lungs are two spongy masses, consisting of arteries, veins, air cells, lymphatics and nerves. These are connected together by cellular substance, and covered by the pleura, or the internal membrane which lines the cavity of the thorax. The air cells of the lungs communicate externally by means of a cartilaginous tube denominated *trachea*, or *windpipe*. The lungs are inclosed in the cavity of the thorax, formed of the twelve dorsal vertebræ posteriorly, the sternum anteriorly, and the ribs laterally. The active powers which enlarge this cavity are principally the *diaphragm*, placed at its inferior part; and the *intercostal muscles*, which fill the spaces between the ribs.

Mechanical Phenomena of Respiration.

Mayaw gives an accurate idea of the respiratory organ, in comparing it to a pair of bellows; in the inside of which there is placed an empty

bladder, whose neck should be adapted to the instrument, and give entrance to a column of air when its parietes are separated. In the same way when the cavity of the thorax is enlarged, there would be a vacuum formed, if the lungs did not expand by the entrance of air and fill up the void. As soon as the muscles, or active powers which enlarge the thorax cease to act, the parts by their elasticity return to their natural situation.

Chemical Phenomena of Respiration.

Respecting the chemical phenomena of the lungs, I have but little to offer; for, notwithstanding the rapid progress which chemical science has made of late years, it is not satisfactorily ascertained, whether the air, or more properly speaking, the oxygenous portion of it, acts negatively, or positively in supporting animal life. Until very lately, it was an opinion I believe almost universally adopted, that it acted positively, but the late experiments of Messrs. Allen and Pepys, seem to prove that it acts negatively: that the whole of the oxygen taken into the lungs is consumed in forming the carbonic acid gas emitted. A portion of caloric is probably set at liberty at the same time, which combines with the blood.

These chemists likewise found that there was no sensible consumption of nitrogen in respiration: the apparent consumption of this gas, observed in some experiments, was a fallacy, and arose from the effect of laborious respiration.—See supplement to a system of chemistry by J. Murray, p. 145. et seq.

But if oxygen act negatively in the coloration of the blood of the adult, it must do so in the fœtus. And if this be the case, I would ask, by what emunctory is the carbonic acid gas set at liberty in the fœtus? does it pass back into the circulation of the mother in some other shape? and does the blood of pregnant women really emit a larger quantity of carbonic acid gas? This, I should suppose, cannot be the case; since the free action of the diaphragm is in a certain degree prevented by the pressure of the uterus and contiguous viscera, in the latter months of gestation.

In whatever manner the air may act, all agree, that the color of the blood is changed, by the processof respiration, during its passage through the lungs, from venous or black, to arterial or a bright red colour, by which it acquires new properties indispensably necessary to the support of life.

SECTION SECOND.

Of the cause of the first inspiration, and of the connexion between the newborn animal and mother, through the medium of the placenta.

The manner in which the first inspiration is effected has attracted the attention of many physiologists; but on no subject has there been more hypotheses advanced. Of these I shall mention some of the least objectionable.

Boerhaave supposes that the fœtus in time of birth, in consequence of its struggles, puts all its muscles into action, and among others the diaphragm. From this cause the thorax becomes expanded, and the air rushes into it; the blood then flows through the vessels of the lungs, and respiration ever afterwards proceeds as in the adult animal.* But should an animal come forth without exerting itself in this manner, which often happens, respiration then according to his theory could never commence. Some other opinions will be noticed presently.

In inquiring into the cause of the first inspi-

* Instit. § 691.

ration, the connexion between the child and mother after birth, by means of the placenta and umbilical cord, should be strictly attended to; since by this communication, the commencement of respiration is often greatly influenced.

It happens in ordinary cases, that the circulation through the cord is kept up moderately vigorous until respiration is established; and it seems to require little or no exertion of the infant. It is still stimulated by the blood from the placenta; while the new element, into which it has been plunged, acts more or less as a stimulant to the whole external surface of the body, but particularly to the irritable and sensible membrane leading from the mouth and nostrils to the lungs. This irritation alone, it is probable, is sufficient to cause the powers which move the thorax (as the diaphragm and intercostal muscles) to be thrown into action.

Dr. Hartley's opinion is not very unlike to Boerhaave's. He imagines that respiration and crying are excited in the newborn child from the cold, handling of the midwife, and other vivid sensations, impressed immediately upon its coming into the world. These sensations tend to throw the whole system of muscles into action;

and in those cases where there are antagonists the stronger will overcome the weaker, and contraction will consequently be produced in them.* That the impressions of cold, light, sound, &c. may assist in the production of these necessary motions there can be little doubt; but I consider them as by no means absolutely essential to the commencement of respiration; and, whatever may be the number of impressions which act at this time, they probably produce but one general sensation, which becomes distinguishable into a number through habit only.

Buffon believes, that when the animal leaves the uterus, the air acts upon all the organs of sensation, but particularly upon the olfactory nerves. They are by this means stimulated; and the animal makes an attempt to sneeze; the capacity of the chest is thus enlarged, the air has liberty to flow into the lungs, and the vesicles become dilated. But the air which is received into them has its temperature increased; and, being expanded, causes the reaction of the fibres of the vesicles, which forces it again out of the chest.† Perhaps the new stimulus of air may act at this time as an errhine, like the snuff of

* Observation on Man, vol. i. p. 95.

† See Nat. Hist. vol. ii. p. 446.

tobacco to those unaccustomed to it, and therefore in this manner have some share in the production of the first inspiration.

Bostock supposes that a change of the position of the child after birth is probably sufficient to account for the commencement of the first inspiration.* But this, though it may favour it, is not certainly sufficient to account for it; and we may suppose that respiration would take place, cæteris paribus, though the child maintained its original position.

In ordinary cases, I believe the first inspiration is not produced by any sense of suffocation, as is spoken of by professor Blumenbach;† any appetite for breathing, or sentient principle, as mentioned by Dr. Whytt;‡ nor to the same cause which forces the adult to respire when he has voluntarily suspended that function for a few seconds, as would seem to be the opinion of the celebrated Baudeloque;§ but, as I formerly mentioned, to the influence of the stimulus of air on the irritability and sensibility of the membrane which lines the

* Essay on Resp. p. 42. et seq. † See Phys.

‡ Whytt, on vital motion.

§ Heath's translation, Vol i. p. 317.

passage leading to the lungs. For agreeably to Bichat every foreign body, coming in contact for the first time with a mucous membrane, produces a disagreable and even painful sensation in it, which is daily diminished until it becomes perfectly insensible. Pessaries in the vagina; suppositories in the rectum; the instrument used in cases of polypus in the nose, or matrix; probes in the urethra, in the œsophagus, or the trachea arteria; stilettoes and setons in the lachrymal passages; invariably present this phenomenon.* The air, which enters the trachea immediately after birth in consequence of its tendency to an equilibrium, must act in the same manner.

In those cases where respiration is established in an inverse ratio to the cessation of the action of the funis or cord, there seems to be no tumult produced in the system of the child; but, when this is not the case, the circulation and oxydation of the blood is performed in an irregular manner. Hence the color of the child often comes and goes repeatedly for the first few moments after birth.

There may be an increased circulation in the

* Vide Bichat's Researches, p. 36.

child after the commencement of respiration, owing to the vigor with which the placenta may still continue to perform its office; or there may be an irregular circulation, from a separation of a part of the placenta, or the contractions of the uterus now emptied of its contents and about to throw off the placenta. On the other hand, the circulation may be increased or diminished, from a speedy or slow establishment of respiration, independent of the mother. The morbid states in which children are born, from an interruption of the functions, or death of the placenta, (if I may so express myself) or from an interruption of the action of the lungs, will be noticed in another place.

Having examined some of the remarkable peculiarities of the fœtus in utero, and the changes which take place immediately after birth; having also inquired into the cause of the first inspiration, and the connexion between the newborn animal and mother through the medium of the placenta; we will proceed in the next section to inquire into the influence of these peculiarities, as indicated by the phenomena attending the life and death of newborn animals, after the separation of the funis; previous to, and after, the establishment of respiration.

SECTION THIRD.

Of the effects of Submersion on living new-born animals.

The peculiar construction of the fœtus, formerly noticed, must necessarily exist immediately after birth; and the obvious analogy between it and the construction of the same parts in the class of animals capable of living in both air and water, called amphibia, induced men of great talents and ingenuity to entertain an opinion that the connexion between the lungs and heart might possibly be dissolved; that the foramen ovale might be kept open, and the blood occasionally circulate as in the fœtus in utero; and that some advantage might possibly be derived from the existence of this structure in animals of the higher order, not excepting even the human species.

This opinion was entertained by Boerhaave, who was distinguished at the time in which he lived, for his extensive acquaintance with every branch of science. He imagines that as long as the foramen ovale and ductus arteriosus are kept open, the animal can continue to live with-

out air, because the blood will then be able to pass from the right to the left side of the heart. He even supposes, that by frequently plunging the young animal in water the closing of these holes might be prevented, and the creature thus rendered amphibious. Why we cannot dilate the chest under water and continue to live in this situation, "hoc nobis κρυπτου est," says he, but he adds "quod forsan vobis vestroque ævo aliquid patescet."*

The important discoveries made in chemistry, since the time of Dr. Boerhaave, have led most of those conversant with the subject, to disregard his observations, yet we find one of our modern philosophers, Dr. Beddoes, coinciding with him, notwithstanding the light thrown on the subject by later inquirers, particularly Dr. Goodwin. Dr. Beddoes observes that, "by frequent immersion in water, the association between the heart and lungs might perhaps be dissolved; and an animal be inured to live commodiously any length of time under water."†

Richerand, a modern physiologist of great ce-

* Prælect. t. V. pars 1. p. 467—474.

† Vide Beddoes on Fact. Airs, p. 41.

lebrity observes, that "it would be interesting to prove, by ocular demonstration, *post mortem*, whether the most expert divers, who can remain the longest time under water without coming to the surface for respiration, have not this aperture (alluding to the foramen ovale) imperfectly shut."*

But the most strenuous advocate for this doctrine is the celebrated French naturalist Buffon. This ingenious man, influenced by the supposition that air was really less essential to the life of a newborn animal than to the adult, tells us that he actually performed an experiment on young dogs for the purpose of determining the question. I shall detail his experiment in his own words: "I procured a pregnant bitch of the greyhound kind; and when just about to litter, I fixed her so in a bucket full of warm water, that her hinder parts were entirely covered. In this situation she brought forth three puppies; which, after being disengaged from their membranes, were immersed in a fluid nearly of an equal temperature, with that of the amnios. After assisting the mother, and washing the puppies in this water, I suddenly removed them in-

* Vide Rich. Phys. p. 431.

to a pail of warm milk, without allowing them time to respire. I put them into the milk in preference to the water, that they might have an opportunity of taking some food, if they found a desire for it. I kept them immersed in milk for more than half an hour; and when taken out of it all the three were alive. They began to breathe; and they discharged a quantity of fluid matter by the mouth. I allowed them to respire about half an hour, and again immersed them in the warm milk, where they remained another half hour. I then took them out: two of them were still vigorous; but the third seemed to languish. I therefore ordered it to be carried to the mother; which, besides the three brought forth in the water, had littered other six in the natural manner. The puppy which was born in water, and had continued one half hour in warm milk before it was allowed to breathe, and another half hour after it had respired, seemed to be very little incommoded; for it soon recovered, and was as active and lively as those which had received no injury. Of the six that were brought forth in the air, I threw away four; so that there remained only two with the mother, besides the one that had been littered in the water. I continued my experiments upon the other two which had been twice immersed in the milk: after al-

lowing them to breathe about half an hour, I plunged them a third time into the milk, where they remained another half hour. Whether they swallowed any of the milk I could not determine; but, when removed, they appeared to be nearly as vigorous as before their immersion. I pushed these trials (says he) no farther: but I learned enough to convince me, that respiration is not so indispensably necessary to a newborn animal as to an adult; and that by employing certain precautions, it is, perhaps, possible to keep the foramen ovale open; and, by this means, produce excellent divers, or a species of amphibious animals, which would be able to live equally in air as in water."*

The relation of so curious an experiment with such minuteness, by such an ingenious writer as Buffon, seems not a little interesting; though most persons acquainted with the theories of the present day would agree with Mr. Bell, in doubting the truth of the relation. But thinking theoretical reasoning, however probable, not always sufficient to invalidate actual experiment, however improbable, I determined to do away all doubt on the subject by repeating the same ex-

* Buffon's Nat. Hist. vol. II. p. 447.

periment. Accordingly I procured a pregnant bitch of the terrier breed, and when she was about to litter, in the month of September 1810, I immersed the hinder parts of the animal in a large vessel of water, which was gradually rising to a temperature equal to that of animal heat. In this situation the animal brought forth a puppy, from which I separated the membranes, but did not effect the separation of the funis umb. or cord, for the space of ten minutes from the time of its expulsion. After the division of the cord, the animal seemed vigorous, and moved about in the water as if swimming; it then threw up, apparently by a sudden and convulsive contraction of the diaphragm, about half a drachm of a whitish coloured fluid, which I supposed to be some of the liquor amnii. It opened its mouth widely once or twice afterwards while it still remained in the water. At the end of fifteen minutes from the separation of the cord, (twenty-five inclusive from its expulsion) the animal seemed quite exhausted. I removed it from the water, and it gasped very weakly, which was the only discoverable sign of life. *Query*, What was the cause of this sudden effort to vomit? Was it the change produced in the qualities and distribution of the blood, by the division of the funis? or was it owing to the action of the cold

water on the skin, or to some which might probably have passed into the stomach?*

EXPERIMENT II.

The second animal, which was expelled an hour after the first, in the water, which had now acquired a degree of heat equal to that of the liquor amnii,† appeared vigorous. I immediately separated the cord, and speedily removed it, without suffering it to respire, from out of the water into a vessel of warm milk, which floated on top of the water, contained in the vessel in which the bitch was placed; and therefore of the same temperature. This animal remained in the milk, into which it was placed, half an hour from the time of the division of the cord; but when removed into the air, showed no sign of life.

EXPERIMENT III & IV.

The third animal remained only a quarter of an hour in the milk after the division of the funis. When removed it was perfectly dead. The subject of this experiment suffered a considera-

* Did not the passage to the lungs close at this time? and, might not this have been the cause of the vomiting? or, was it the effect?

† During this and the remainder of the experiments, the mercury fluctuated between the 96 and 98° F.

ble hemorrhage from the cut end of the navel string.

The fourth puppy remained also a quarter of an hour in the milk after the division of the cord, and afforded the same result.

EXPERIMENT V.

The fifth whelp I suffered to come forth in the open air; after having breathed for half an hour and taken some nourishment, it was placed in milk of its own temperature. It was suffered to remain in this situation a quarter of an hour; at the end of which time it was removed into the air. The animal gasped several times in the course of the first six or eight minutes after its removal; but did not recover.

EXPERIMENT VI.

The sixth puppy I caused to be littered in the warm water: it was, after the same manner as the others, placed directly into the milk after the separation of the membranes; but the cord was not divided, as the placenta came along at the same time. This puppy was found quite dead, apparently, at the end of one quarter of an hour from the time of its expulsion.

The seventh puppy, less unfortunate than its kindred, was not made a subject of experiment. It thrived well, and grew very large in the course of a few weeks.

All these experiments, except the first, were witnessed by Mr. Chandler of Philadelphia, who very politely assisted me in conducting them.

Appearance on dissection.

Those animals, that never breathed, exhibited on dissection an appearance somewhat different from that which breathed. The appearances of the former were as follows:

1. The lungs were of a purplish red colour, and as might be expected, in a state of complete collapse.

2. The thymus gland was nearly of the colour of the lungs, but somewhat lighter.

3. The colour of the heart was of a pale red; with the right and left auricle, and coronary vein distended with black blood. The auricles of the heart, particularly the right, renewed their contractions shortly after exposure to the air, though the animals had been dead several hours.

4. The ascending and descending cavæ; the pulmonary veins; and the venous system generally, were distended with black blood.

5. The ventricles contained some blood.

6. The arterial system generally seemed to be empty, except the upper part of the aorta, which contained a small portion of black blood.

7. The texture of the blood was not very compact; it approached towards a fluid state by agitation, and seemed to melt away when taken between the fingers, like lard.

The appearance of the animal which breathed half an hour before immersion, on opening the body was as follows:

1. The lungs were distended with air, except at their margins, and of a very light redish colour.

2. The thymus gland of this animal was much whiter than in those that did not breathe, which excited my attention.

3. The heart was somewhat darker, and the auricles were not quite so much distended; but the blood in them was as black, or perhaps blacker, than in the others. They did not possess so much apparent irritability; for the contractions of the right auricle were feeble and less perceptible than the same auricle of those animals which never breathed.

4. The liver was somewhat darker than those of the other animals.

5. The texture of the blood was firmer.

These are the principal phenomena noticed on dissection.

From these experiments and dissections we may draw the following conclusions:

1. That air is as indispensably necessary to newborn animals as to adults, either through the medium of the supposed function of the placenta, or that of the lungs; and that the experiments of M. Buffon are proved to be erroneous; for death ensues in a very short time after the separation of the cord, provided respiration be not established.—Exp. I. IV. & VI.

2. That the placenta, in all probability, oxygenates the blood of the fœtus; as the action of the heart, which had ceased after the separation of the funis, again renewed its contractions on being laid bare and exposed to the air.—See the dissections.

3. That an animal which breathes for a short time after birth is not deprived of the signs of life so soon by submersion as those which never breathe.—See experiment V.

4. That it also suffers a greater commotion during the act of dying; and the excitability of the heart is less than those animals which die before the commencement of respiration. See experiment V. and dissections.

5. That its blood is more fibrous and stronger than the blood of those animals which die from immersion, previous to the establishment of respiration.—See dissections.

Dissection showed the thymus gland of that animal which respired, and took nourishment to be much whiter than the thymi of those which never respired, and took no nourishment. To what cause was this remarkable difference ow-

ing? What communication is there between this viscus and the thoracic duct? does it admit the chyle? I am disposed to believe that it does. What change it may effect in the chyle I know not. May it not answer nearly the same purpose, to the thoracic duct, that Dr. Rush supposes the spleen does to the blood vessels, namely, to absorb a portion of chyle when this is in overproportion, or flows with too much rapidity, and give it out again when it becomes deficient? May not this idea be supported by the following circumstances?

1. From the vicinity of this viscus to the large trunk of the thoracic duct.

2. It is said to have no excretory duct.

3. From the phenomenon mentioned by anatomists, which manifests itself on cutting into the substance of this gland, and applying pressure, namely, an appearance of a whitish fluid like milk.

4. From the irregular manner in which children are supplied with food. It is well known that they are not masters of their appetites; have no judgment of the proper quantity they

should take; and therefore make their appetites their only guide: hence Rousseau tells us, that all children are gluttons. 2d. Children often, on the other hand, are unable to express their wants; or, being neglected, cannot help themselves; and therefore suffer for the want of food.

5. Children require a greater quantity of food for their growth and nourishment, independent of other circumstances; and therefore a greater provision was necessary, to fortify the system against the ill consequences that might arise from this source, than for the adult. From what has been said we may also learn the reason why the thymus gland disappears in proportion as the body arrives towards maturity, and the judgment becomes perfected.

Should this office, which I have assigned to the thymus gland be admitted, it will apply to pathology, and explain why children are in some measure exempt from several of the diseases of adults, as pulmonary consumption, &c. Dr. Biglow who graduated in this university a few years since, supposed that the reason, why children are less liable to pulmonary consump-

tion than adults, is because the thymus gland answered to defend the lungs, by diverting the blood therefrom. But I would suppose that the thymus, by drawing a portion of fresh chyle from the general mass, when superabundant, and pouring it out when deficient in quantity, might obviate debility, both indirect and direct; which is the predisposing cause of disease; and in this manner protect the system, not only from pulmonary consumption, but many other diseases.*

After this digression on the subject of the function of the thymus gland, I proceed to offer a few remarks on the death of newborn animals, and the means of recovering those children in which resuscitation may be practicable.

* Dr. Rush kindly informs me that he has met with a number of cases of pulmonary consumption in children; and that many of the subjects, in which he has seen it, were from ten to twelve or fourteen years of age. May not the thymus gland be previously affected in such cases? and should this not induce us to examine such by dissection whenever an opportunity may offer itself?

SECTION IV.

Of the manner in which the death of newborn animals takes place; and the means of restoring them in those cases where resuscitation may be practicable.

The fact has been long ago ascertained by Dr. Goodwin, that death from submersion is not produced directly, from the water which enters the lungs, but indirectly by excluding the atmospheric air.* It must be obvious that those animals which were brought forth in water, viz. the subjects of the four first, and sixth experiments, could not have died directly, from the entrance of water into the lungs, since they were in a state of collapse. They must therefore have died indirectly from the interruption of the mother's blood, by the divison of the cord, or from the prevention of the establishment of respiration.

Dr. Goodwin also first confirmed the opinion of Lower, respecting the changes which the blood underwent during its passage through the lungs. This he did, by removing the sternum of

* Goodwin's Essay. § II.

several large dogs, and exposing to view the pulmonary artery and veins, so as to allow him to distinguish accurately the colour of the blood that passed through them. He then inflated the lungs with a pair of bellows, imitating the natural respiration, and kept the animal alive by this process for a considerable length of time. In these experiments it was observed that, during the inflation, the blood in the trunks of the pulmonary artery was black; but in the trunks of the pulmonary veins it was florid; and when the inflation was intermitted for a minute, the blood in the trunk of the pulmonary vein became gradually black, like that in the arteries.*

He also found, "by inflating the lungs when the sternum is removed, and the pericardium opened in such a manner that the motion of the auricles may be distinctly perceived, and attending carefully to the changes in the colour of the blood, and in the corresponding contractions in the left auricle and ventricle of the heart, that when the blood which passed into the left ventricle was florid, the auricle and ventricle contracted strongly, and the circulation went on as in health; but when the blood began to put on a shade of brown, the contractions were dimi-

* Goodwin's Essay, p. 29.

nished; and when it was black, the contractions ceased, although the auricle was distended with blood; and as the contractions ceased, the functions of the body were suspended; but as soon as the florid colour began to be restored, the auricle and ventricle resumed their contractions, and they gradually recovered their natural state; and all the other functions returned." From this experiment he concludes, that the chemical quality, which the blood acquires in passing through the lungs, is necessary to keep up the action of the heart, and consequently the health of the body.

The ingenious Bichat has farther divided the phenomena of life into animal and organic: the former he defines to be that which connects us with the numerous bodies which surrounds us, and belongs exclusively to the animal; while the latter consists only in organic texture, and is common to both the vegetable and animal kingdoms. Animals possessing both these lives are destroyed, according to him, from the influence of black blood on all the organs, in the following order:

* Essay, p. 36.

1st. There is an interruption of the chemical phenomena of the lungs. 2d. A suspension of cerebral action. 3d. A cessation of the sensations, voluntary locomotion, and mechanical phenomena of respiration. 4th. An annihilation of the action of the heart, and of general circulation. 5th. A termination of the capillary circulation, of the secretions, absorption, and consequently of digestion. 6th. A cessation of animal heat, which is the result of all the functions, and which does not abandon the body so long as any of them remain in activity.*

But in those animals where the chemical and mechanical phenomena of the lungs are supplied by the mother, or (as we are inclined to believe) by the funcion of the placenta, (as in newborn animals,) animal life, of course, has never commenced. It is the organic life only which is destroyed by, first, an interruption of the function or death of the placenta; secondly, by the annihilation of the action of the heart, and of the general circulation, &c.

There is greater commotion experienced by animals drowned after the commencement of

* Bichat's Phys. Researches, p. 237.

respiration, as appears from the experiments related in the third section of this essay; and the excitability of the heart, and probably all the other organs, is more completely exhausted, than in those that have never respired.—See the section containing the experiments and dissections.

For this reason I have no doubt but artificial means to recover newborn infants may be more successfully employed, in cases of suspended animation from an interruption of the action of the placenta, than of the lungs. We shall therefore offer, in the next place, a few directions for the recovery of those wherein it may be thought practicable.

Children are frequently born in a state of asphyxia, or syncope; which happens from the gradual cessation of the action of the funis, either before delivery, or after this has taken place, provided respiration is not established. In this instance I presume, that the arteries of the umbilical cord continue to propel their blood back into the system of the mother, longer than the child receives any from the vein. Here the quantity and quality of the blood are insufficient to support the child in a healthy manner: it experiences a partial or complete syncope. This I

suppose is accompanied with the same uneasy sensation about the precordia, as generally attends this affection in adults; and which professor Blumenbach, Dr. Darwin, and others, assign as the common cause of the first inspiration. And though I suppose this not to take place in ordinary cases, yet here I believe it really does. And that this idea is well founded, I infer from the phenomena exhibited just before death by animals dying of hemorrhage: we see them gasping widely, and at the same time perceive the thorax greatly enlarged. This dying gasp, therefore, I am inclined to believe, is often the cause of the resuscitation of animals born in a state of asphyxia, or syncope, by giving air access to the lungs. But artificial means in these cases should never be neglected.

Again, children are often born in a livid and apparently in an apoplectic state, from a sudden interruption of the circulation between the mother and child; either from the mechanical pressure of the cord or otherwise. This prevents the blood from returning from the system of the child by the umbilical arteries, and of its arrival by the vein; hence the system of the child becomes surcharged, or engorged with blood. In this case the circulation between the mother

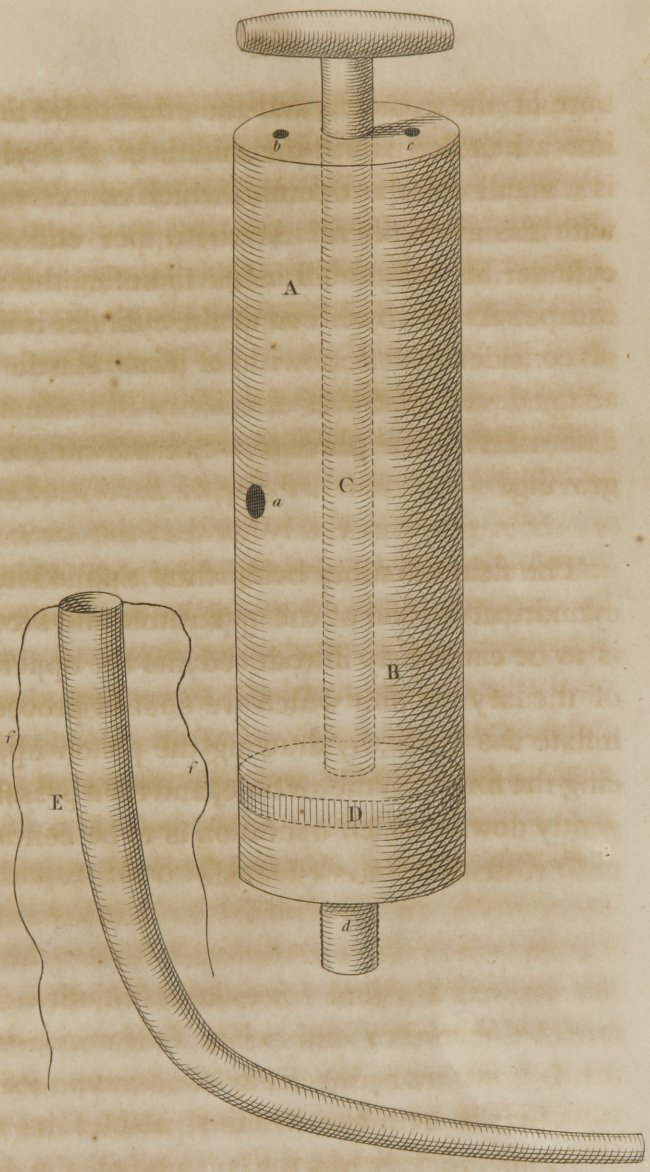
and child cannot be restored; there is a necessity for removing pressure from the brain, as well as to oxygenate the blood; therefore respiration is absolutely necessary. Our object should be immediately to cut the cord, deplete the system by allowing it to bleed one or two ounces, and resort to artificial means for establishing respiration. For here the mechanical phenomena of respiration formerly mentioned cannot take place naturally.

In those cases, where these artificial means are to be made use of, it will be proper to clear the mouth and fauces, &c. of mucus, should any exist there, by suspending the infant a short time by the heels, or to use a piece of fine linen wrapped around the little finger for the purpose. It will likewise be proper to accommodate the temperature of the child's body according to circumstances.

For the inflation of the lungs, I propose an instrument which differs in some respects from that recommended by Dr. Goodwin for the recovery of adults. It consists of a small ivory cylinder whose bore is four inches long, and one and a quarter in diameter, with a piston made of wood, one end of which is to fill completely the

bore of the cylinder, and the other to be formed into a handle. About the middle of the cylinder is a small circular opening which communicates with the atmosphere. At the upper end of the cylinder are two small holes to suffer the air to escape. At the lower end of the cylinder is a hole of considerable size with a gum elastic tube adapted, which by its flexibility will accommodate itself to the passage.—See the annexed engraving.

The flexible tube, being thus applied to the cylindrical portion of the apparatus, and secured, is to be cautiously introduced into the upper part of the larynx; after which we should proceed to inflate the lungs, by drawing the piston up, placing the finger on the air hole, and then pressing it gently down; which operation is to be continued until resuscitation is effected.



A B *the ivory cylinder.*
C D *the piston.*
a the air hole.
b c two holes to let the air escape.
d the orifice of communication between the cylinder and tube.
E *the flexible gum elastic tube.*
f f two small strings for the purpose of securing it.